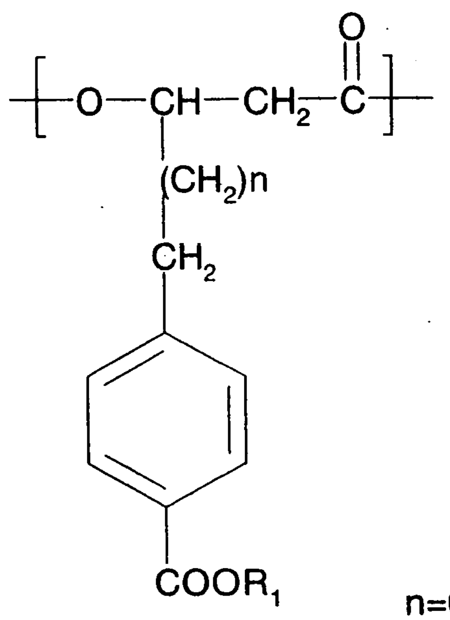
CLAIMS

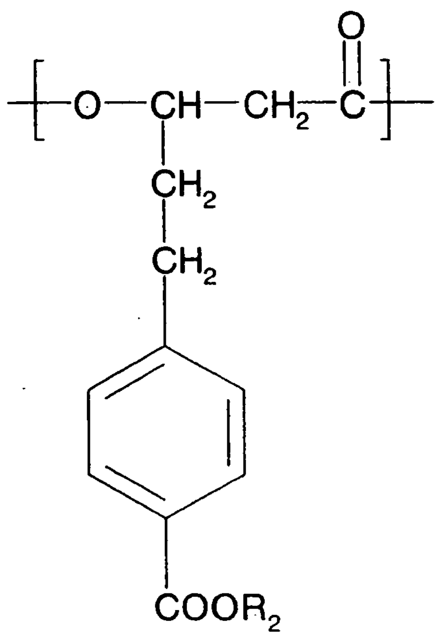
1. A polyhydroxyalkanoate containing in a molecule thereof one or more 3-hydroxy-ω-(4-carboxyphenyl)alkanoic acid units represented by a chemical formula (1):



n=0-7 (1)

wherein n is an integer selected from 0 to 7; R_1 is an H, Na or K atom; and when more than one unit exists, n and R_1 may differ from unit to unit, respectively.

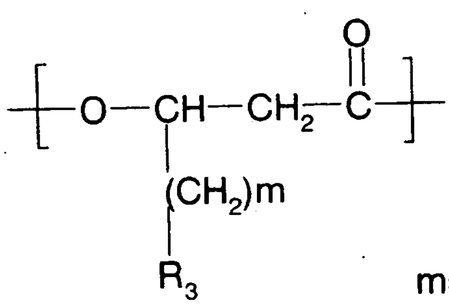
2. The polyhydroxyalkanoate according to claim 1, wherein the 3-hydroxy-ω-(4-carboxyphenyl)alkanoic acid unit represented by the chemical formula (1) is a 3-hydroxy-ω-(4-carboxyphenyl)valeric acid unit represented by a chemical formula (2):



(2)

wherein R_2 is an H, Na or K atom and, when more than one unit exists, it may differ from unit to unit.

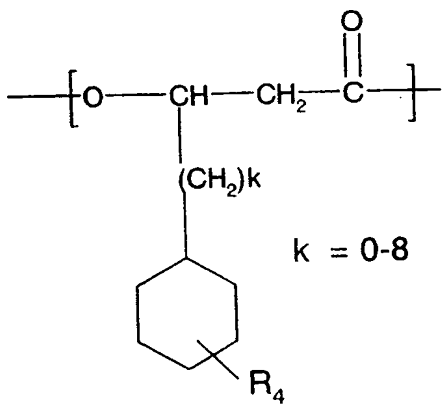
3. The polyhydroxyalkanoate according to claim 1, wherein the polyhydroxyalkanoate contains, besides the 3-hydroxy-ω-(4-carboxyphenyl)alkanoic acid unit represented by the chemical formula (1), at least either a 3-hydroxy-ω-substituted alkanoic acid unit represented by a chemical formula (3):



m=1-8 (3)

wherein m is an integer selected from 1 to 8; R_3 comprises a residue having a ring structure of either a phenyl or a thienyl structure; and when more than one unit exists, m and R_3 may differ from unit to unit, respectively; or

a 3-hydroxy-ω-cyclohexylalkanoic acid unit represented by a chemical formula (4):

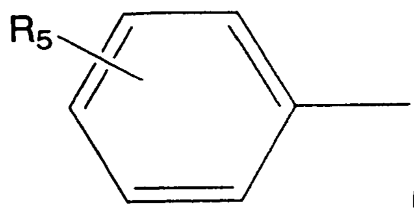


(4)

wherein R_4 represents a substituent on a cyclohexyl group and is an H atom, a CN group, an NO_2 group, a halogen atom, a CH_3 group, a C_2H_5 group, a C_3H_7 group, a CF_3 group, a C_2F_5 group or a C_3F_7 group; k is an integer selected from 0 to 8; and when more than one unit exists, k and R_4 may differ from unit to unit.

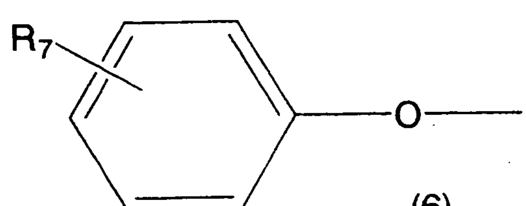
4. The polyhydroxyalkanoate according to claim 1, wherein R_3 in the chemical formula (3) having a phenyl or thienyl structure is at least any one selected from the group consisting of residues represented by chemical formula (5), (6), (7), (8),

(9), (10), (11), (12), (13), (14) and (15),
wherein the chemical formula (5) represents a group consisting of unsubstituted and substituted phenyl groups:



(5)

wherein R_5 represents a substituent on the aromatic ring and is an H atom, a halogen atom, a CN group, an NO_2 group, a CH_3 group, a C_2H_5 group, a C_3H_7 group, a $CH=CH_2$ group, $COOR_6$ (R_6 represents any one of H, Na and K atoms), a CF_3 group, a C_2F_5 group or a C_3F_7 group; and when more than one unit exists, R_5 may differ from unit to unit;
the chemical formula (6) represents a group consisting of unsubstituted and substituted phenoxy groups:

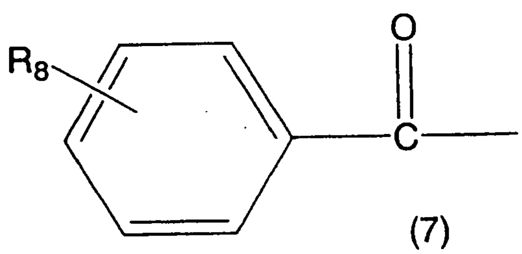


(6)

wherein R_7 represents a substituent on the aromatic ring and is an H atom, a halogen atom, a CN group, an NO_2 group, a CH_3 group, a C_2H_5 group, a C_3H_7 group, an

SCH_3 group, a CF_3 group, a C_2F_5 group or a C_3F_7 group; and when more than one unit exists, R_7 may differ from unit to unit;

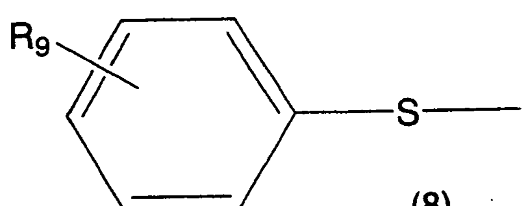
the chemical formula (7) represents a group consisting of unsubstituted and substituted benzoyl groups:



(7)

wherein R_8 represents a substituent on the aromatic ring and is an H atom, a halogen atom, a CN group, an NO_2 group, a CH_3 group, a C_2H_5 group, a C_3H_7 group, a CF_3 group, a C_2F_5 group or a C_3F_7 group; and when more than one unit exists, R_8 may differ from unit to unit;

the chemical formula (8) represents a group consisting of unsubstituted and substituted phenylsulfanil groups:

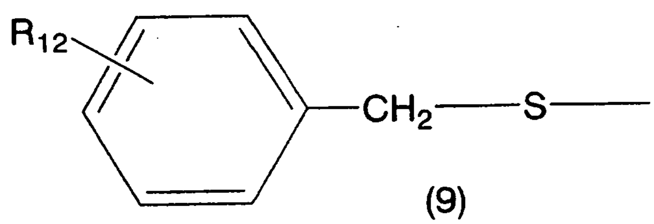


(8)

wherein R_9 represents a substituent on the aromatic ring and is an H atom, a halogen atom, a CN group, an NO_2 group, a $COOR_{10}$, an SO_2R_{11} (R_{10} represents any one

of an H atom, an Na atom, a K atom, a CH_3 group and a C_2H_5 group and R_{11} represents any one of an OH group, an ONa group, an OK group, a halogen atom, an OCH_3 group and OC_2H_5 group), a CH_3 group, a C_2H_5 group, a C_3H_7 group, a $(CH_3)_2$-CH group or a $(CH_3)_3$-C group; and when more than one unit exists, R_9 may differ from unit to unit;

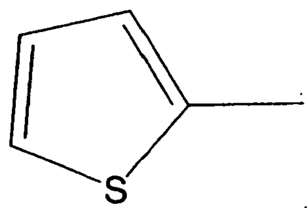
the chemical formula (9) represents a group consisting of unsubstituted and substituted (phenylmethyl)sulfanil groups:



(9)

wherein R_{12} represents a substituent on the aromatic ring and is an H atom, a halogen atom, a CN group, an NO_2 group, a $COOR_{13}$, an SO_2R_{14} (R_{13} represents any one of an H atom, an Na atom, a K atom, a CH_3 group and a C_2H_5 group and R_{14} represents any one of an OH group, an ONa group, an OK group, a halogen atom, an OCH_3 group and OC_2H_5 group), a CH_3 group, a C_2H_5 group, a C_3H_7 group, a $(CH_3)_2$-CH group or a $(CH_3)_3$-C group; and when more than one unit exists, R_{12} may differ from unit to unit;

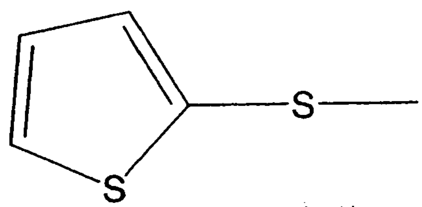
the chemical formula (10) represents 2-thienyl group:



(10)

;

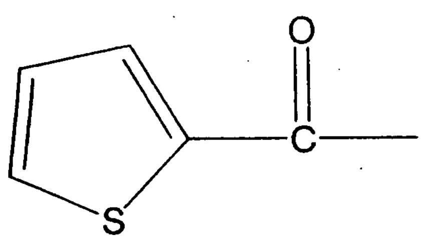
the chemical formula (11) represents a 2-thienylsulfanil group:



(11)

;

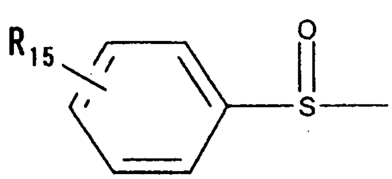
the chemical formula (12) represents a 2-thienylcarbonyl group:



(12)

;

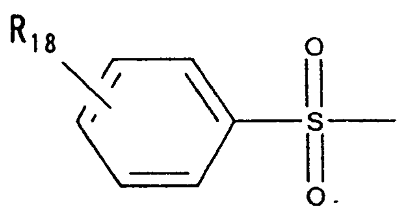
the chemical formula (13) represents a group consisting of unsubstituted and substituted phenylsulfenyl groups:



(13)

wherein R_{15} represents a substituent on the aromatic ring and is an H atom, a halogen atom, a CN group, an NO_2 group, a $COOR_{16}$, an SO_2R_{17} (R_{16} represents any one of an H atom, an Na atom, a K atom, a CH_3 group and a C_2H_5 group and R_{17} represents any one of an OH group, an ONa group, an OK group, a halogen atom, an OCH_3 group and OC_2H_5 group), a CH_3 group, a C_2H_5 group, a C_3H_7 group, a $(CH_3)_2$-CH group or a $(CH_3)_3$-C group; and when more than one unit exists, R_{15} may differ from unit to unit;

the chemical formula (14) represents a group consisting of unsubstituted and substituted phenylsulfonyl groups:

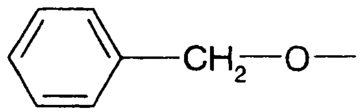


(14)

wherein R_{18} represents a substituent on the aromatic ring and is an H atom, a halogen atom, a CN group, an NO_2 group, a $COOR_{19}$, an SO_2R_{20} (R_{19} represents any one of an H atom, an Na atom, a K atom, a CH_3 group and a C_2H_5 group and R_{20} represents any one of an OH group, an ONa group, an OK group, a halogen atom, an OCH_3 group and OC_2H_5 group), a CH_3 group, a C_2H_5 group, a C_3H_7 group, a $(CH_3)_2$-CH group or a $(CH_3)_3$-C group; and when more than one unit exists, R_{18} may differ from

unit to unit; and

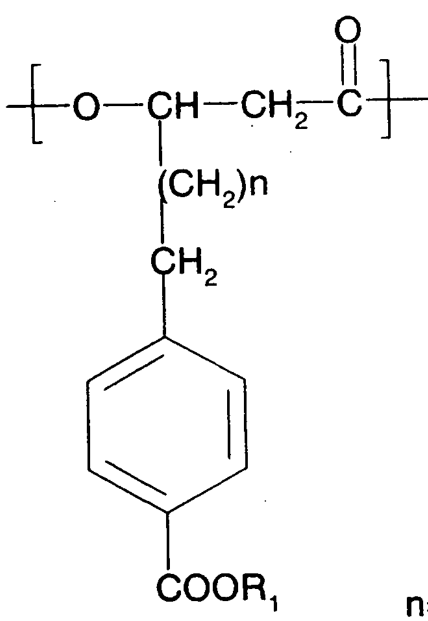
the chemical formula (15) represents a group of a (phenylmethyl)oxy group:



(15)

5. The polyhydroxyalkanoate according to claim 1, wherein a number average molecular weight of the polyhydroxyalkanoate is selected to fall in a range of 1000 to 1000000.

6. A process for preparing a polyhydroxyalkanoate represented by the chemical formula (1):

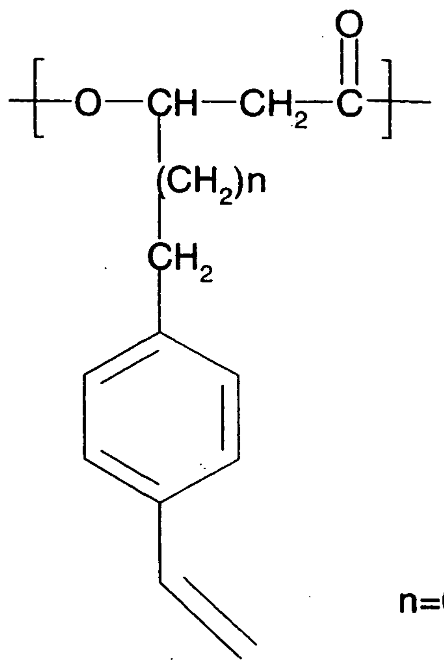


n=0-7 (1)

wherein n is an integer selected from 0 to 7; R_1 is an H, Na or K atom; and when more than one unit exists, n and R_1 may differ from unit to unit, respectively,

the process comprising the steps of:

preparing, as a raw material, a 3-hydroxy-ω-(4-vinylphenyl)alkanoic acid unit represented by the chemical formula (16):

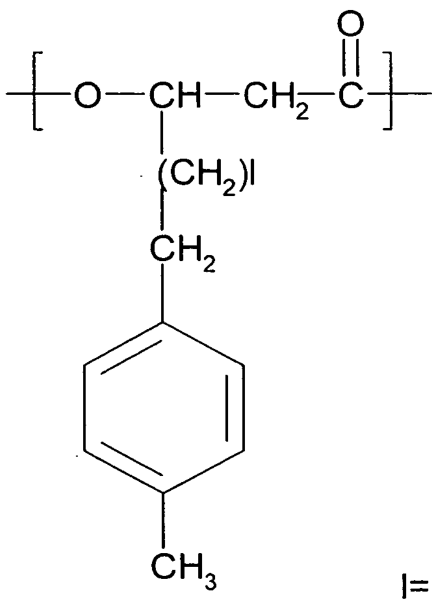


n=0-7 (16)

wherein n is an integer selected from 0 to 7; and when more than one unit exists, n may differ from unit to unit,

or

3-hydroxy-ω-(4-methylphenyl)alkanoic acid unit represented by the chemical formula (17):

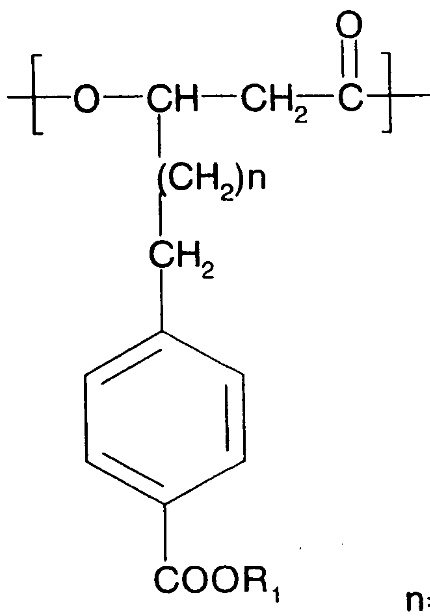


l=0-7 (17)

wherein l is an integer selected from 0 to 7; and when more than one unit exists, l may differ from unit to unit; and

oxidizing the double bond portion of the polyhydroxyalkanoate represented by the chemical formula (16) or the methyl group portion of the polyhydroxyalkanoate represented by the chemical formula (17).

7. A process for preparing a polyhydroxyalkanoate comprising at least both 3-hydroxy-ω-(4-carboxyphenyl)alkanoic acid unit represented by the chemical formula (1):

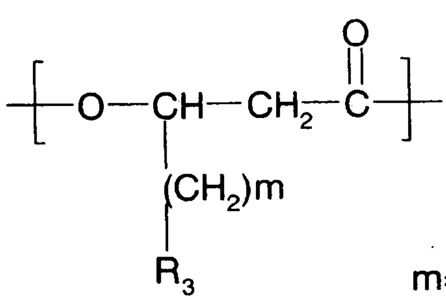


n=0-7 (1)

wherein n is an integer selected from the range shown in the formula; R_1 is an H, Na or K atom; and when more than one unit exists, n and R_1 may differ from unit to unit, respectively,

and

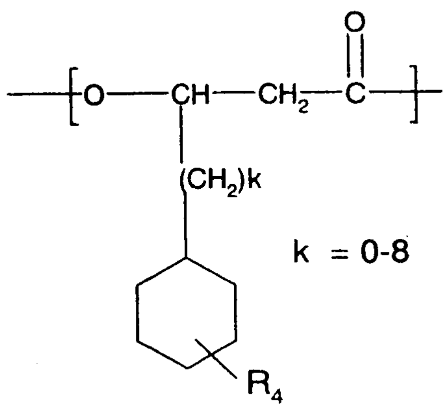
3-hydroxy-ω-substituted alkanoic acid units represented by the chemical formula (3):



m=1-8 (3)

wherein m is an integer selected from the range shown in the formula; R_3 comprises a residue having a ring structure of either a phenyl or a thienyl structure;

and when more than one unit exists, m and R_3 may differ from unit to unit, respectively, or 3-hydroxy-ω-cyclohexylalkanoic acid units represented by the chemical formula (4):

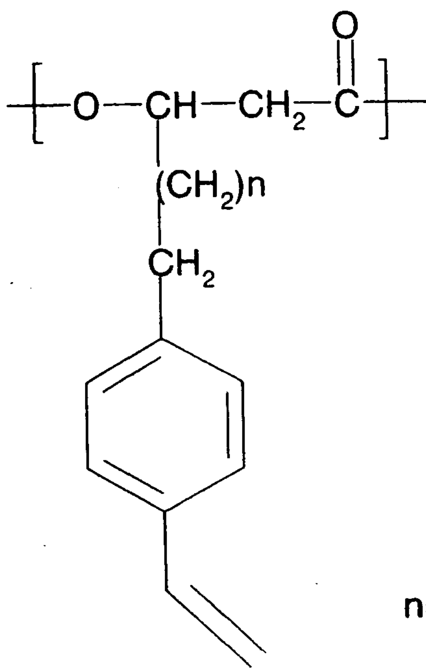


(4)

wherein R_4 represents a substituent on the cyclohexyl group and is an H atom, a CN group, an NO_2 group, a halogen atom, a CH_3 group, a C_2H_5 group, a C_3H_7 group, a CF_3 group, a C_2F_5 group or C_3F_7 group; k is an integer selected from the range shown in the formula; and when more than one unit exists, R_4 and k may differ from unit to unit, respectively,

the process comprising the steps of:

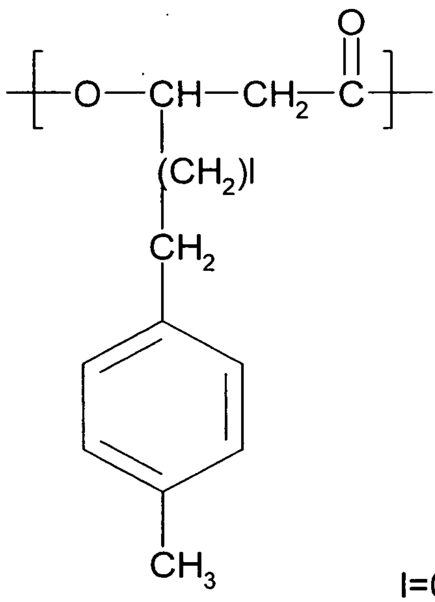
preparing, as a raw material, a polyhydroxyalkanoate comprising at least both 3-hydroxy-ω-(4-vinylphenyl) alkanoic acid unit represented by the chemical formula (16):



n=0-7 (16)

wherein n is an integer selected from 0 to 7, and when more than one unit exists, n may differ from unit to unit,

or 3-hydroxy-ω-(4-methylphenyl)alkanoic acid unit represented by the chemical formula (17):

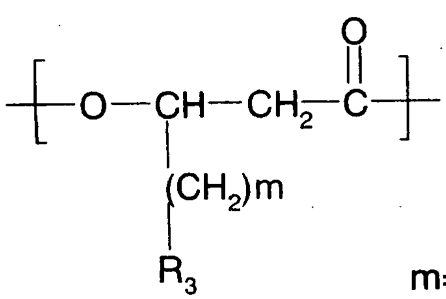


l=0-7 (17)

wherein l is an integer selected from 0 to 7; and when more than one unit exists, l may differ from unit to unit;

and

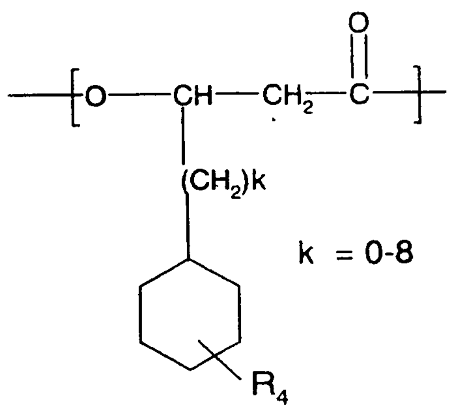
3-hydroxy-ω-substituted alkanoic acid unit represented by the chemical formula (3):



m=1-8 (3)

wherein m is an integer selected from the range shown in the formula; R_3 comprises a residue having a ring structure of either a phenyl or a thienyl structure; and when more than one unit exists, m and R_3 may

differ from unit to unit, respectively,
or 3-hydroxy-ω-cyclohexylalkanoic acid units represented by the chemical formula (4):



(4)

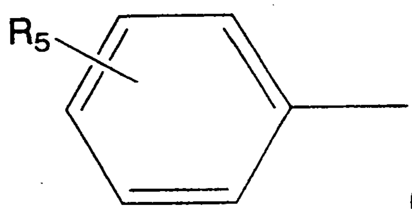
wherein R_4 represents a substituent on the cyclohexyl group and is an H atom, a CN group, an NO_2 group, a halogen atom, a CH_3 group, a C_2H_5 group, a C_3H_7 group, a CF_3 group, a C_2F_5 group or C_3F_7 group; k is an integer selected from the range shown in the formula; and when more than one unit exists, R_4 may differ from unit to unit; and

oxidizing the double bond portion of the polyhydroxyalkanoate represented by the chemical formula (16) or the methyl group portion of the polyhydroxyalkanoate represented by the chemical formula (17).

8. The process for preparing a polyhydroxyalkanoate according to claim 7, characterized in that R_3 in the chemical formula (3),

namely a residue having a phenyl or a thienyl structure has at least any one chemical formula selected from the group consisting of chemical formulae (5), (6), (7), (8), (9), (10), (11), (12), (13), (14) and (15),

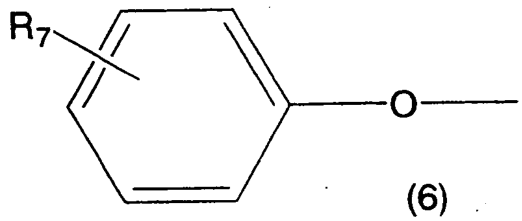
wherein the chemical formula (5) is a group consisting of unsubstituted and substituted phenyl groups represented by



(5)

wherein R_5 represents a substituent on the aromatic ring and is an H atom, a halogen atom, a CN group, an NO_2 group, a CH_3 group, a C_2H_5 group, a C_3H_7 group, a $CH{=}CH_2$ group, $COOR_6$ (R_6 represents any one of H, Na and K atoms), a CF_3 group, a C_2F_5 group or a C_3F_7 group; and when more than one unit exists, R_5 may differ from unit to unit,

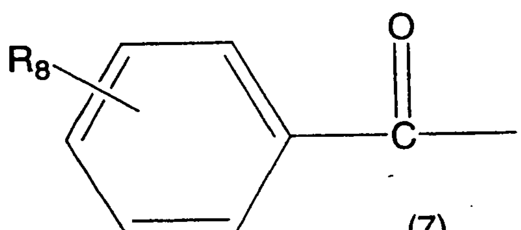
the chemical formula (6) is a group consisting of unsubstituted and substituted phenoxy groups represented by



(6)

wherein R_7 represents a substituent on the aromatic ring and is an H atom, a halogen atom, a CN group, an NO_2 group, a CH_3 group, a C_2H_5 group, a C_3H_7 group, an SCH_3 group, a CF_3 group, a C_2F_5 group or a C_3F_7 group; and when more than one unit exists, R_7 may differ from unit to unit,

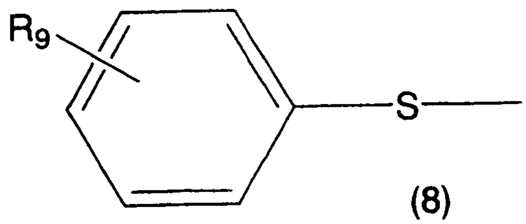
the chemical formula (7) is a group consisting of unsubstituted and substituted benzoyl groups represented by



(7)

wherein R_8 represents a substituent on the aromatic ring and is an H atom, a halogen atom, a CN group, an NO_2 group, a CH_3 group, a C_2H_5 group, a C_3H_7 group, a CF_3 group, a C_2F_5 group or a C_3F_7 group; and when more than one unit exists, R_8 may differ from unit to unit,

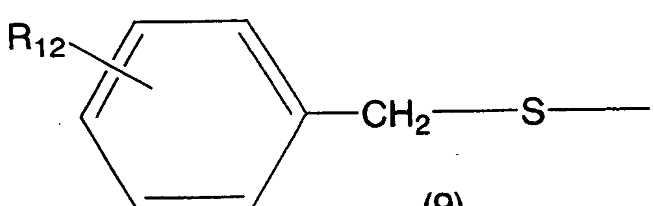
the chemical formula (8) is a group consisting of unsubstituted and substituted phenylsulfanil groups represented by



(8)

wherein R_9 represents a substituent on the aromatic ring and is an H atom, a halogen atom, a CN group, an NO_2 group, a $COOR_{10}$, an SO_2R_{11} (R_{10} represents any one of an H atom, an Na atom, a K atom, a CH_3 group and a C_2H_5 group and R_{11} represents any one of an OH group, an ONa group, an OK group, a halogen atom, an OCH_3 group and OC_2H_5 group), a CH_3 group, a C_2H_5 group, a C_3H_7 group, a $(CH_3)_2$-CH group or a $(CH_3)_3$-C group; and when more than one unit exists, R_9 may differ from unit to unit,

the chemical formula (9) is a group consisting of unsubstituted and substituted (phenylmethyl)sulfanil groups represented by

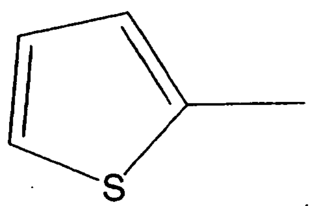


(9)

wherein R_{12} represents a substituent on the aromatic ring and is an H atom, a halogen atom, a CN group, an NO_2 group, a $COOR_{13}$, an SO_2R_{14} (R_{13} represents any one of an H atom, an Na atom, a K atom, a CH_3 group and a

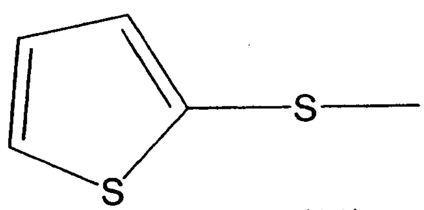
C_2H_5 group and R_{14} represents any one of an OH group, an ONa group, an OK group, a halogen atom, an OCH_3 group and OC_2H_5 group), a CH_3 group, a C_2H_5 group, a C_3H_7 group, a $(CH_3)_2$-CH group or a $(CH_3)_3$-C group; and when more than one unit exists, R_{12} may differ from unit to unit,

the chemical formula (10) is 2-thienyl group represented by



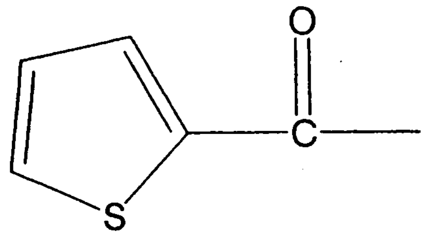
(10)

the chemical formula (11) is 2-thienylsulfanyl group represented by



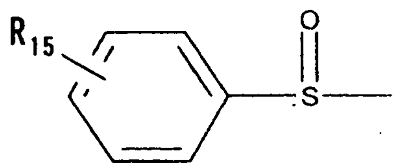
(11)

the chemical formula (12) is a 2-thienylcarbonyl group represented by



(12)

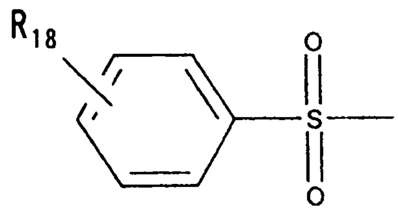
the chemical formula (13) is a group consisting of unsubstituted and substituted phenylsulfynyl groups represented by



(13)

wherein R_{15} represents a substituent on the aromatic ring and is an H atom, a halogen atom, a CN group, an NO_2 group, a $COOR_{16}$, an SO_2R_{17} (R_{16} represents any one of an H atom, an Na atom, a K atom, a CH_3 group and a C_2H_5 group and R_{17} represents any one of an OH group, an ONa group, an OK group, a halogen atom, an OCH_3 group and OC_2H_5 group), a CH_3 group, a C_2H_5 group, a C_3H_7 group, a $(CH_3)_2$-CH group or a $(CH_3)_3$-C group; and when more than one unit exists, R_{15} may differ from unit to unit,

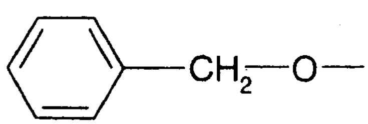
the chemical formula (14) is a group consisting of unsubstituted and substituted phenylsulfonyl groups represented by



(14)

wherein R_{18} represents a substituent on the aromatic ring and is an H atom, a halogen atom, a CN group, an NO_2 group, a $COOR_{19}$, an SO_2R_{20} (R_{19} represents any one of an H atom, an Na atom, a K atom, a CH_3 group and a C_2H_5 group and R_{20} represents any one of an OH group, an ONa group, an OK group, a halogen atom, an OCH_3 group and OC_2H_5 group), a CH_3 group, a C_2H_5 group, a C_3H_7 group, a $(CH_3)_2$-CH group or a $(CH_3)_3$-C group; and when more than one unit exists, R_{18} may differ from unit to unit, and

the chemical formula (15) is a group of a (phenylmethyl)oxy group represented by



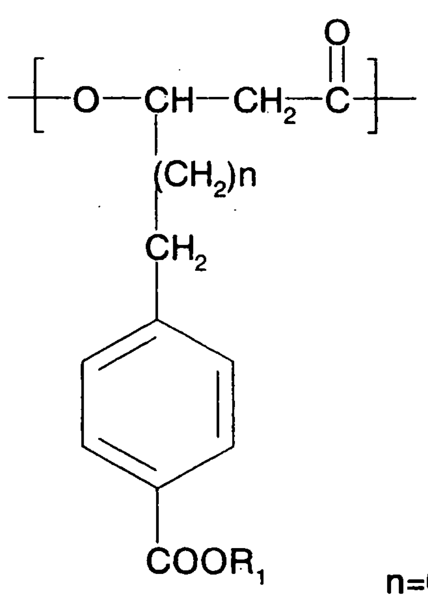
(15)

9. The process for preparing a polyhydroxyalkanoate according to claim 6, wherein the oxidizing step is carried out by using one or more oxidizing agents selected from the group consisting of permanganate, bichromate and periodate.

10. The process for preparing a polyhydroxyalkanoate according to claim 9, wherein the oxidizing step is carried out by using a permanganate, as an oxidizing agent, under acid conditions.

11. The process for preparing a polyhydroxyalkanoate according to claim 6, wherein the oxidizing step is carried out by using ozone.

12. A resin composition comprising a resin (A) and a thermoplastic resin (B), the resin (A) being a polyhydroxyalkanoate that contains, in a polymer molecule thereof, at least one kind of unit of the 3-hydroxy-ω-(4-carboxyphenyl)alkanoic acid units represented by the chemical formula (1):



n=0-7 (1)

wherein n is an integer selected from the range shown in the formula; R_1 is an H, Na or K atom; and when more than one unit exists, n and R_1 may differ from unit to unit, respectively.

13. The resin composition according to claim 12, wherein the polyhydroxyalkanoate is the one according to claim 2.

14. The resin composition according to claim 12, wherein the thermoplastic resin (B) comprises one or more resins selected from the group consisting of polyester-based resin, polystyrene-based resin, polypropylene-based resin, polyethylene terephthalate-based resin, polyurethane-based resin, polyvinyl-based resin and polyamide-based resin.

15. The resin composition according to claim 14, wherein the polystyrene-based resin is polystyrene.

16. The resin composition according to claim 12, wherein the polyester-based resin is poly-ε-caprolactone or polylactic acid.

17. The resin composition according to claim 12, further comprising additives for resin.

18. A molding molded from a resin composition according to claim 12.

19. The molding according to claim 18, wherin the molding is a container.

20. The molding according to claim 21, wherein the molding is at least any one selected from the group consisting of containers for foods, drinks, toiletries, drugs and cosmetics.

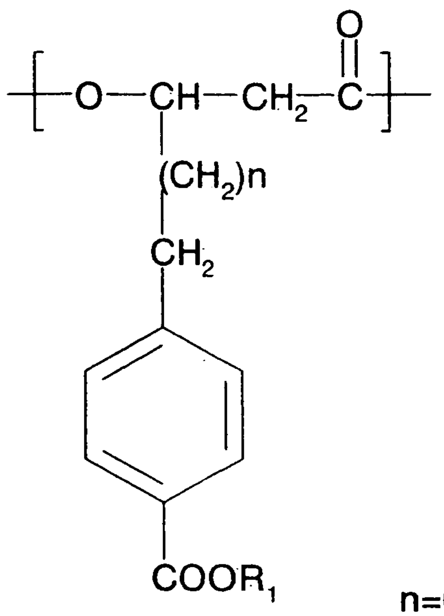
21. The molding according to claim 18, wherein the molding is biodegradable.

22. The molding according to claim 18, wherein the molding is used in a temperature environment of 140°C or less.

23. A method of producing a molding comprising heating a resin composition according to claim 12 for molding.

24. A charge controlling agent for controlling a charged state of powder and granular materials, the agent comprising a polyhydroxyalkanoate that has at least one kind of unit selected from the group consisting of the 3-hydroxy-ω-(4-

carboxyphenyl)alkanoic acid units represented by the chemical formula (1):



n=0-7 (1)

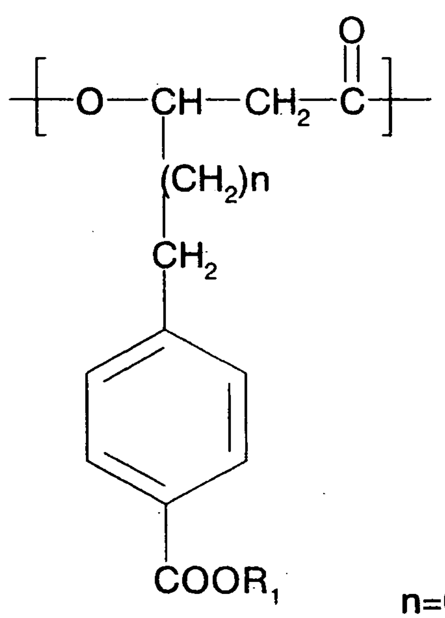
wherein n is an integer selected from the range shown in the formula; R_1 is an H, Na or K atom; and when more than one unit exists, n and R_1 may differ from unit to unit, respectively.

25. The charge controlling agent according to claim 24, wherein the polyhydroxyalkanoate is a polyhydroxyalkanoate according to claim 2.

26. The charge controlling agent according to claim 24, wherein the powder and granular material is a toner for developing electrostatic latent images.

27. A toner for developing an electrostatic latent image comprising at least a binder resin, a colorant and a charge controlling agent according to claim 24.

28. A binder resin for forming a resin-based powder and granular material comprising a polyhydroxyalkanoate whose polymer molecule comprises at least one kind of unit selected from the group consisting of the 3-hydroxy-ω-(4-carboxyphenyl)alkanoic acid units represented by the chemical formula (1):



n=0-7 (1)

wherein n is an integer selected from the range shown in the formula; R_1 is an H, Na or K atom; and when more than one unit exists, n and R_1 may differ from

unit to unit, respectively.

29. The binder resin according to claim 28, wherein the polyhydroxyalkanoate is the one according to claim 2.

30. The binder resin according to claim 28, wherein the resin further comprises a thermoplastic resin, besides the polyhydroxyalkanoate, and a content of the polyhydroxyalkanoate is larger than that of the thermoplastic resin.

31. The binder resin according to claim 30, wherein the resin further comprises a resin composition according to claim 14.

32. The binder resin according to claim 30, wherein the thermoplastic resin is one or more selected from the group consisting of polycaprolactone and polylactic acid.

33. The binder resin according to claim 28, wherein the resin has a number average molecular weight of 2,000 or more and 300,000 or less.

34. The binder resin according to claim 28, wherein the binder resin has a glass transition point

of 30 to 80°C and a softening point of 60 to 170°C.

35. The binder resin according to claim 28, wherein the resin-based powder and granular material is a toner for developing electrostatic latent images.

36. A toner for developing electrostatic latent images containing a binder resin according to claim 28.

37. An image forming method comprising at least the steps of:

charging an electrostatic latent image-holding member by applying voltage to a charging member from outside;

forming an electrostatic latent image on the charged electrostatic latent image-holding member;

developing the electrostatic latent image with a toner for developing electrostatic latent images to form a toner image on the electrostatic latent image-holding member;

transferring the toner image on the electrostatic latent image-holding member to a recording medium; and

fixing the toner image on the recording medium by heat,

wherein the toner is a toner according to claim

27.

38. The image forming method according to claim 37, wherein the transferring step comprises a first transferring step of transferring the toner image on the electrostatic latent image-holding member to an intermediate transfer medium; and a second transferring step of transferring the toner image on the intermediate transfer medium to the recording medium.

39. An image forming apparatus comprising at least charging means for charging an electrostatic latent image-holding member by applying voltage to a charging member from outside; electrostatic latent image forming means for forming an electrostatic latent image on the charged electrostatic latent image-holding member; developing means for developing the electrostatic charge image with a toner for developing electrostatic charge images to form a toner image on the electrostatic latent image-holding member; transferring means for transferring the toner image on the electrostatic latent image-holding member to a recording medium; and fixing means for fixing the toner image on the recording medium by heat, wherein the toner for developing electrostatic charge images is a toner according to claim 27.

40. The image forming apparatus according to claim 39, wherein the transferring means comprises a first transferring means for transferring the toner image on the electrostatic latent image-holding member to an intermediate transfer medium; and a second transferring means for transferring the toner image on the intermediate transfer medium to the recording medium.